

 STATINTL

PROPOSAL FOR
A FEASIBILITY STUDY

of an

ULTRA HIGH RESOLUTION
VIEWER

2 October 1962

DECLASS REVIEW by NIMA/DOD

 STATINTL

TABLE OF CONTENTS

	<u>Page</u>
1.0 PROPOSAL SUMMARY	1
2.0 INTRODUCTION	3
3.0 STUDY OBJECTIVES	6
4.0 FEASIBILITY AND DESIGN STUDIES	7
5.0 PROGRAM MANAGEMENT AND SCHEDULE	11
6.0 COMPANY CAPABILITIES	13
7.0 PERSONNEL QUALIFICATIONS	15
APPENDIX A	

1.0 PROPOSAL SUMMARY

STATINTL [] is pleased to submit the following proposal, the objective of which is to investigate the feasibility of two promising approaches to viewing high resolution photographs. If feasible, these approaches will enable viewers to be built which will avoid the loss of tonal gradation inherent in diffusion screens and still permit a variable magnification of 50x or greater.

The approaches to be studied are:

- a. The development of a non-diffusing screen material, and
- b. A technique employing a crossed diffraction grating in the optical image plane.

During the conduct of the study, breadboard apparatus, suitable for laboratory investigation and confirmation of the theoretical approaches will be constructed. The results achieved with this equipment will provide information for preliminary design studies and layouts of feasible approaches, with the intent of confirming technical, optical, and human engineering factors. Recommendations will be made for one or more approaches to

be undertaken for detailed design and fabrication of operational equipment.
A brief summary of any new manufacturing methods required will also
be provided.

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will be assisted in the initial optical study and
breadboard optical fabrication by

The study will be completed by sixteen weeks from the date of receipt
of the contract.

2.0 INTRODUCTION

Recent improvements in films, optics, camera design, and viewing techniques have led to photographic images possessing greatly increased quantities of interpretable detail. As is always the case, it is difficult to keep all parts of a system equalized in efficiency. One of the weaker links in the development of modern systems is the viewing apparatus.

All recording systems have limits. Despite the capability of the photographic emulsion to collect vast amounts of graphic data, interpretability is limited in areas of underexposed shadow and overexposed highlight. While some improvement in emulsion latitude may be achieved, this limitation is always likely to exist. The photo interpreter will therefore continue to be faced with the basic problem of recognizing and identifying the information he seeks among almost formless objects whose tonal gradations may or may not be significant.

The photo interpreter is also required to view large amounts of material continually and rapidly. This requires that the viewing equipment be designed to place the least possible physical and

visual strains on the photo interpreter. The rear projection viewer has evolved as one of the most useful solutions to this latter problem: since it does not require the user to fix his eyes to viewing oculars for long periods of time, and permits him to assume a comfortable position in a normal environment. The penalty paid for this convenience and flexibility, however, is an additional loss of subtle image tonal gradations, resulting from the use of a diffusion screen to view the projected image. This is unavoidable, since the very purpose of the diffusion screen is to diffuse the image-forming light falling on it, over a viewing angle acceptable to the user. In image areas containing very small contrast differences, the image signal, in effect, becomes submerged in the "noise" inherent in the diffusing medium.

Some work has also been done on the design of viewers in which the interpreter may view a virtual image in space, without any screen whatsoever. Virtual image viewing permits a substantial improvement to be made in preserving and presenting to the user such subtle tonal gradations as are present in the transparency, and this has encouraged exploration of this method by the development of hardware. Because of the resolution of the transparency image, the size of common formats, and other related factors, it is necessary to view important parts of the material under magnification powers of up to 50x. Unfortunately,

theory and experience indicate that virtual image projection viewers are limited to a maximum magnification factor of about 4.5x. This is true for either reflective or refractive systems (see Appendix).

The problem is therefore to attain, as closely as possible the quality of the virtual image, but with the realistic requirement of being able to utilize powers of magnification compatible with the nature of the input materials.

3.0 STUDY OBJECTIVES

It will be the objective of the proposed study to determine the feasibility of a new class of ultra high resolution rear projection viewers with the following general performance features:

- A. A minimal loss of image contrast through the use of techniques other than diffusion screens.**
- B. Magnification variable between 2x and 50x.**
- C. Resolving power at greatest magnification approaching 400 l/mm (film plane resolution)**
- D. Field of view at the smallest magnification not smaller than 2-3/4" square and preferable 5" square.**
- E. A viewing system which will permit measurements to be made of the projected images.**

The approaches to be investigated in the attainment of these goals are described in the following section.

4.0 FEASIBILITY AND DESIGN STUDIES

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has developed two new and promising concepts of implementing rear projection viewing without sacrificing acuity or magnification. These concepts involve the use of a crossed diffraction grating as a screen and/or the development of a non-diffusing material as a screen. Both of these concepts will be examined in detail during the proposed program and preliminary data will be developed. These techniques can be briefly described as follows:

4.1 Non-Diffusing Screen. One means of avoiding image contrast losses due to diffusion screens would be to replace the diffusion screen in a rear projection viewer with a fibre optics screen. The cost of a screen of this type, in the size needed, would probably be prohibitive. However, other possible means of generating an equivalent effect will be studied. If proven to be sound theoretically, a preliminary investigation of sources and costs of fabrication will be undertaken.

One approach might be defined as a "fibre-less" optical system. Instead of fibres, a screen made of small cylindrical holes is used, the internal walls of the cylinders being coated with reflective material.

The manufacture of a screen of this sort should not be so difficult or costly as the straight fibre optics approach. Photo sensitive chemically etchable glass may prove to be one practical method of fabrication. There are a number of other possible techniques for fabricating screens of this nature which will also be considered.

4.2 Crossed Diffraction Grating. The second approach proposed for study would focus the image on a crossed diffraction grating. A zoom, or similar lens system, would be used to project the image onto the grating through a field lens. When properly designed, the observer should be able to view directly what is in effect an array of small exit pupils which are aligned to form one large exit pupil. This is represented schematically in Figure 1.

While such a system would normally appear to work only with monochromatic light (e. g. , the yellow sodium D line), it may be possible to circumvent this restriction by overlapping the elementary pupils or by using two or more spectral sources to provide the effect of white light. Theoretical aspects of effective pupil size and the inherent problems of designing a useful system of this type will require investigation during the conduct of the study.

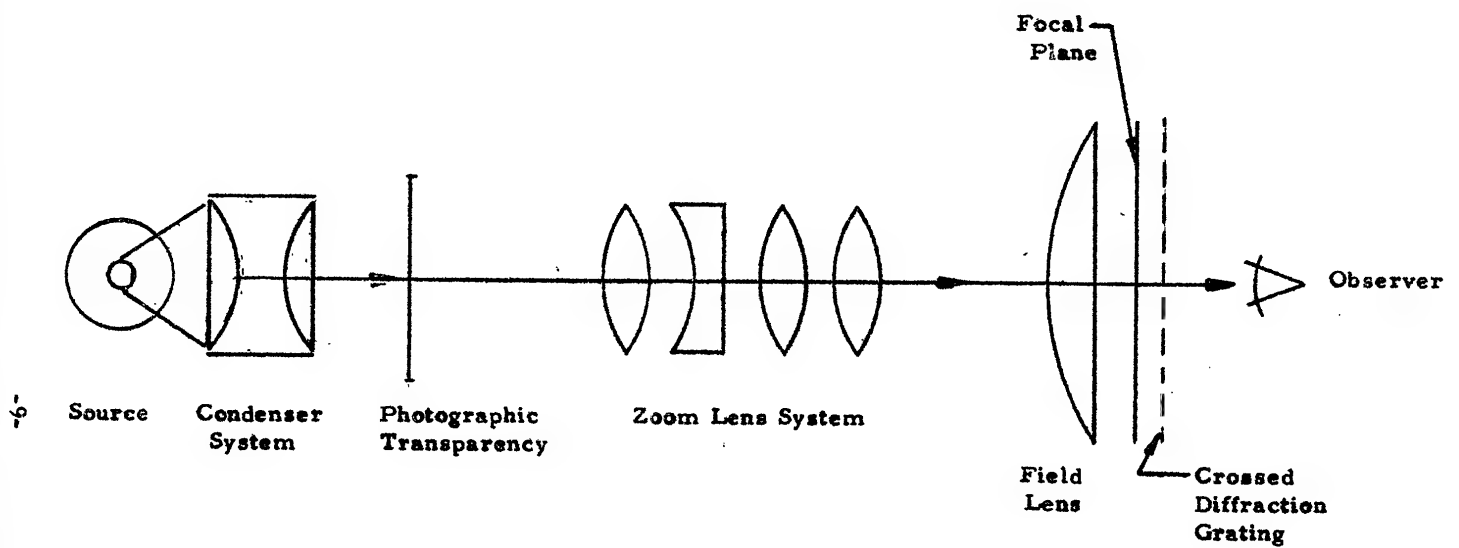


FIGURE 1. SCHEMATIC DIAGRAM OF PROPOSED DIFFRACTION GRATING VIEWING SYSTEM.

4.3 Duality of Approach: While each of these methods shows promise for rear projection viewing, it cannot be predicted which unique approach will yield optimal results in terms of performance and economy. Therefore, breadboard apparatus will be constructed and bench tests will be undertaken for each approach. Indicative performance data will be obtained, and unique fabrication problem assessed to aid in the selection of the optimal method. Based upon the results of these efforts, recommendations will be prepared and submitted relating to specific operational hardware designs.

5.0 PROGRAM MANAGEMENT AND SCHEDULE

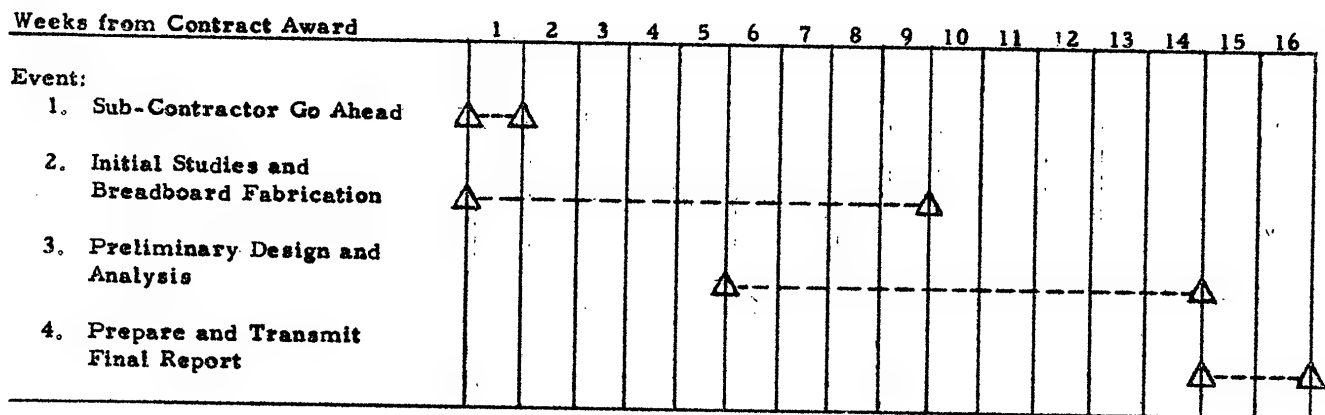
STATINTL The proposed study program will be conducted under the direction of the []
STATINTL [] will personally direct the theoretical study, analysis, and preliminary design effort to be accomplished during the course of the study.

STATINTL [] will be assisted in the optical study and breadboard optical fabrication by []
[]
STATINTL will be under the auspices of [] who will be
STATINTL assisted by [] and others.

Analysis of the study results, preliminary mechanical-optical design studies and layouts, and a final report including recommendations will be provided by []
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Figure 2 presents a tentative schedule for the proposed program.

Fig. 2 PROGRAM SCHEDULE



6.0 COMPANY CAPABILITIES

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was organized to serve the electro-photo-optical market by providing a capability for the conception of advanced equipment and systems and the related development, production and support of these equipments and systems. In order to satisfy these objectives in today's rapidly changing environment, it is essential to blend a thorough understanding of the requirements and limitations of advanced devices and techniques with a thorough understanding of the current state-of-the-art and future potential of electro-photo-optical equipments and systems.

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is specifically tailored to serve this market.

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is focusing its efforts on the development and manufacture of electro-photo-optical equipments and systems in the reconnaissance, data handling, photogrammetry and photo interpretation fields. The company possesses special competence in those areas of physics, engineering and systems management where electronics, photography, and optics have merged to produce new basic techniques and equipments.

The technical staff and scientific resources of the company are prepared to provide a "quick reaction" capability for the resolution of electro-photo-optical problems of a broad or specialized equipment nature.

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was founded in 1959 by senior optical designers and master craftsmen who had worked together as a team for many years. The company is oriented toward the design and fabrication of optical elements, as well as research toward the advancement of the theory and art of optics. Typical of the products produced are tiny prisms, 30-inch diameter mirrors finished to two millionths of an inch over the entire surface, and large germanium lenses. Optical components are designed and manufactured in single units or thousand lots to the strictest commercial and military requirements.

The company possesses unique fabrication and test equipment, largely of their own design since available commercial equipment was unsatisfactory for the exacting standards demanded by the nature of its efforts.

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7.0 PERSONNEL QUALIFICATIONS

The company's personnel have extensive backgrounds in the design, development, production, field support and management of high performance advanced systems development programs. During the accumulation of this experience they have pioneered and made significant technical contributions to the advancement of the state-of-the-art in photographic equipments, concepts, techniques, and related ground and data handling devices.

Resumes of the personnel to be associated with the proposed study follow.



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Next 7 Page(s) In Document Exempt

APPENDIX A

The principle limitation of true virtual image viewers, namely limited magnification at useful exit pupils diameters, is basic and independent of the degree of system complexity. Consider the following:

- (a) The magnification M and effective focal length f' are related by the equation:

$$M = \frac{10}{f'}$$

where 10 inches is a typical viewing distance.

- (b) Given the effective focal length f' , the diameter D of the exit pupil is determined by the aperture angle 2θ at the object side according to the equation:

$$D = 2f' \sin \theta$$

Consequently,

$$M = \frac{20 \sin \theta}{D}$$

Considering that D should not be smaller than $3\frac{1}{2}$ " , the maximum value of the magnification is:

$$M \leq 5.7$$

This maximum may be increased in two ways: (1) it is assumed in the above proof that the operator's eyes are accommodated at infinity. If we drop this condition, then the maximum value of M will increase by about 10%.

(2) If the film is immersed in a high index oil, the maximum value of M is multiplied by the index of the oil.

It must be understood, however, that the maximum magnification calculated in this way is a theoretical value which may not be expected to be ever attained in practice. Our experience indicates that a magnification of $4\frac{1}{2}$ is a realistic maximum.